

SUPERCONDUCTIVITY IN THE Sn-Ba-Sr-Y-Cu-O SYSTEM

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Since Bednorz and Müller /1/ discovered high- T_c superconductivity in the La-Ba-Cu-O compound, several families of superconducting oxides have been synthesized /2/. In this paper we report the results of search for superconductivity in the compounds based on tin which has a lone electron pair like Bi, Tl, Pb.

The following compounds were synthesized: $\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x$, $\text{Sn}_1\text{Ba}_1\text{Ca}_1\text{Cu}_3\text{O}_x$, $\text{Sn}_1\text{Ba}_1\text{Mg}_1\text{Cu}_3\text{O}_x$, $\text{Sn}_1\text{Sr}_1\text{Ca}_1\text{Cu}_3\text{O}_x$, $\text{Sn}_1\text{Sr}_1\text{Mg}_1\text{Cu}_3\text{O}_x$, $\text{Sn}_1\text{Ca}_1\text{Mg}_1\text{Cu}_3\text{O}_x$. The initial components were oxides and carbonates of the appropriate elements. Standard firing-grinding procedure was used. Final heating was carried out at 960°C during 12 hours. Then the samples were cooled inside the furnace. All the synthesis cycles were carried out in air atmosphere.

Among the synthesized compounds only $\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x$ showed remarkable conductivity ($\rho \sim 10 \text{ Ohm}\cdot\text{cm}$). Other compounds were practically dielectrics ($\rho > 1000 \text{ Ohm}\cdot\text{cm}$). Presence of a possible superconductivity in $\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x$ was defined by using the Meissner effect. At low temperature a deviation from paramagnetic behaviour is observed. The hysteresis loops obtained at lower temperatures undoubtedly testify to the presence of a superconductive phase in the sample. However, the part of the superconductive phase in the $\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x$ ceramic turned out to be small, less than 2%, which agrees with the estimation from magnetic data. In order to increase the content of the superconductive phase two-valent cations Ba, Sr were partially substituted by univalent (K) and three-valent ones (Y). Two samples were obtained: $\text{Sn}_1\text{Ba}_{0.7}\text{Sr}_{0.7}\text{K}_{0.7}\text{Cu}_3\text{O}_x$ and $\text{Sn}_1\text{Ba}_{0.7}\text{Sr}_{0.7}\text{Y}_{0.7}\text{Cu}_3\text{O}_x$. The former is a typical paramagnet without any anomaly down to 4.2K. The latter has shown the magnetic and electric properties undoubtedly indicating the presence of a superconductivity phase with the onset temperature $T_c \approx 55\text{K}$. The superconductive properties of the sample do not seem to be caused by the phase $\text{YBaSrCu}_3\text{O}_7$ /3/. This conclusion follows from the study of the $\text{Sn}_2\text{Sr}_2\text{Ba}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$ and $\text{Sn}_2\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$ samples that were synthesized by analogy with the recent communications on superconductivity in $\text{Pb}_2\text{Sr}_2(\text{Y}, \text{Ca})_1\text{Cu}_3\text{O}_8$ /4,5/. One may expect equal probability of the $\text{YBaSrCu}_3\text{O}_7$ content for both samples, however their electrical properties are quite different. The compound $\text{Sn}_2\text{Sr}_2\text{Ba}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$ is a good dielectric while $\text{Sn}_2\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$ has clearly expressed superconductive properties /6/. The magnetic moment was measured in an external field $H = 100 \text{ Oe}$. At $T < 86\text{K}$ the sample exhibits a clearly defined diamagnetic behaviour characteristic of superconductors. At these temperatures the hysteresis loop has the form typical of high- T_c superconductors. The amount of the superconductive phase in this sample, as a magnetic estimation in powder, is $\sim 15\%$ of the volume of the sample.

A comparative analysis of the X-ray powder diagrams leads us to believe that the main motive of the $\text{Y}_1\text{Ba}_2\text{Cu}_3\text{O}_7$ structure is preserved in the structure of $\text{Sn}_2\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$. The unit cell parameters are: $a = 4.1 \text{ \AA}$, $c = 12.4 \text{ \AA}$ (or multiple).

We have also used the same procedure for $\text{Sn}_1\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x$. The sample is a typical paramagnet without any anomaly down to 4.2 K.

The presence of superconductivity in the system based on tin allows us to suggest that other cations, besides the well-known Bi, Tl, Pb, having the lone electron pair effect, should also form superconductive compounds. If we limit ourselves to consideration of copper-containing oxides, we may suppose that definite alkali-earth ions (or their combination) would suit for each of the ions: Hg, Sb, In, ... in order to form a superconductive phase.

References

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